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(54) Title: METHOD AND ARRANGEMENT FOR INTERFERENCE CANCELLATION
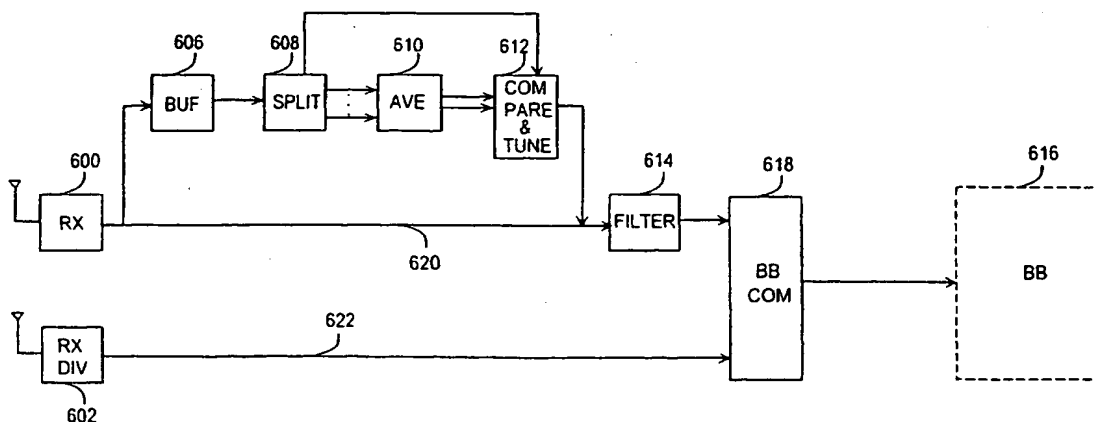
(57) Abstract: The object of the invention is to provide a method and an arrangement which allow to avoid significant degradation in performance of a broadband system receiver or even blocking of the receiver, caused by simultaneous use of the same frequency or simultaneous use of adjacent frequencies by a narrowband and a broadband communications systems, or background noise peaks produced by a plurality of various man-made interference signals. In one preferred embodiment of the invention, the energy of the received signal is determined in narrower sub-bands (400), the average of the sub-band signal energies is calculated (402), the energies of the sub-band signals are compared with said average (404) and if any of the sub-band signal energies exceeds the average by a predetermined threshold value, interference is cancelled by a tunable band-stop filter (406 to 408).

1

METHOD AND ARRANGEMENT FOR INTERFERENCE CANCELLATION

FIELD OF THE INVENTION

The invention relates to a method and arrangement for cancelling harmful narrowband interference signals or reducing interference caused by
5   these signals in broadband communications systems, such as cellular radio systems.

BACKGROUND OF THE INVENTION

In cellular radio systems, background noise, which is modelled as AWGN (Additive White Gaussian Noise) and various interferences, such as
10 interference signals or fading multipath-propagated signals may be summed to a signal on a radio channel. One way to improve the reliability of data transmission is to use spread spectrum technique. The spread spectrum methods are data transmission methods, in which the signal is transmitted on a much broader bandwidth than the minimum bandwidth required for data transmis
15 sion. Figure 1 shows the schematic structure of a spread spectrum system. The signal spectrum is spread in a transmitter on the frequency level after information modulation 100 by using a pseudo-random spreading code 102, which is independent of the original, generally digital, information signal. In a receiver, the signal is despread by multiplying the signal again by the spread
20 ing code 104, whereafter the signal is demodulated 106. The performance of the spread spectrum system against interference signals is often detected by detection amplification, which represents improved signal-to-noise ratio in the receiver. Because the interference does not generally correlate with the spreading code, the despreading of the spectrum in the receiver is spreading
25 modulation in view of interference, i.e. the interference signal resembles common noise on the channel, and as the information signal is a narrowband signal after despreading, most of the interference can be filtered off, which provides detection amplification.

A method, in which all users transmit simultaneously using the
30 same frequency band and in which the signals of different users can be distinguished in receivers on the basis of the spreading code by using a specific spreading code on each communication connection between a base station and a mobile station, is called the code division multiple access method CDMA. Cross correlation properties of the spreading codes will be minimized
35 by selecting the codes to be used such that they are mutually orthogonal. In

2

WCDMA (Wideband Code Division Multiple Access) receivers the correlators are in synchronization with the signal to be identified on the basis of the spreading code. The signals that have been multiplied by some other code in the transmission stage, do not correlate, in an ideal case, with the code used

5   for multiplication and thus they will remain in broadband format. Hence, they appear as noise in view of the desired signal. The object is thus to detect the desired user signal among a plurality of interfering signals. In practice, the spreading codes are not uncorrelated, because the number of mutually orthogonal codes is insufficient, and therefore the signals of other users produce

10   error in the detection of the desired signal by distorting the received signal non-linearly.

In the future, the same or an adjacent frequency band can be simultaneously used by a plurality of cellular radio systems, typically a narrowband system, such as the GSM (Global system for Mobile Communications) or

15   the PDC (Pacific Digital Cellular System), and a broadband system, such as the WCDMA system). In simultaneous use of the same frequency or simultaneous use of an adjacent frequency, the broadband system is typically used for high-rate data transmission and the narrowband system for speech transmission. Figure 2 shows a typical overlay use situation. A base station 204 of

20   the narrowband NB system forms there a narrowband cell 200 and a base station 206 of the WCDMA system forms a broadband cell 202. Narrowband transmission 210 interferes with receivers of both the broadband base station and subscriber terminal 208. In this kind of simultaneous use, improved performance provided by detection amplification of the broadband system is not

25   always sufficient, but the broadband signal having considerably higher power can significantly deteriorate the receiver performance of the broadband system, such as the WCDMA system, or even block it. The WCDMA system is interference limited, so that interference reduces either capacity or coverage area. It appears from Figure 3 how the narrowband signal 302 power is con-

30   siderably higher than the broadband signal 300 power, which is close to the power level of background noise. Since the broadband signal resembles AWGN noise on the channel, it does not cause extra interference in the receiver of the narrowband system. In addition to the power level of the interfering signal, many other factors, such as the duration of interference, the modu-

35   lation method and encoding used, affect the performance, i.e. tolerance to various interference, of the cellular radio systems.

3

Methods have been presented attempting to reduce degradation in performance caused to the receiver of the broadband system by the narrow-band system in the simultaneous use of the same frequency band. In known methods, interference cancellation generally requires that various mathemati-

5 cal transformation methods of signals be used for regenerating the signal and the interference, which takes time and computing capacity, or, the interference cancellation is implemented in baseband frequency parts, even though it should be implemented at the earliest possible stage. The known methods, in which interference cancellation is implemented in radio frequency parts and in

10 which the signal and the interference need not be regenerated, are based on available advance information on the interfering system. One method of this kind is disclosed in "Experimental WCDMA data overlay of GSM network" by Noël and Widdowson, British Telecom Res. Labs., *Electronic Letters*, 15 April 1999, Vol. 35, Issue 8, which is incorporated herein by reference. Said publi-

15 cation describes a method which attempts to cancel interference caused by a narrowband signal as close to the radio frequency parts as possible to mini-mize the effects of interference by using a band-stop filter tuned to a prede-termined frequency. The described method has a drawback that the frequency used by the interfering system must be known in order to be able to tune the

20 band-stop filter. Often, this is only possible if the broadband system and the interfering narrowband system are used by the same operator. In addition, the performance of narrowband systems is often improved, particularly in multi-path propagation environments, by using frequency hopping which allows the interfering narrowband signal to change the frequency it uses in the frequency

25 band of the broadband system. In this case, tuning the band-stop filter in ad-vance onto one frequency does not improve the performance sufficiently. A narrow band-stop filter is not sufficiently efficient either for cancelling interfer-ence caused by background noise peaks, such as microwave ovens or car starting systems, generated by a plurality of other man-made interference sig-

30 nals. Typically, also in these situations, signals, which cause interference in the receiver band of the broadband system, vary as a function of time, and therefore it is not possible to know their frequencies in advance in order for the filter to be tuned.

4

BRIEF DESCRIPTION OF THE INVENTION

The object of the invention is to provide a method and an arrange-
ment implementing the method which allows to avoid a significant degradation
in performance of a broadband system receiver or even blocking of the re-

5   ceiver, caused by simultaneous use of the same frequency or simultaneous
use of adjacent frequencies by a narrowband and a broadband communica-
tions systems, or background noise peaks, such as microwave ovens or car
starting systems, produced by a plurality of various man-made interference
signals. This is achieved by a method for cancelling interfering narrowband

10   signals in a receiver of a broadband communications system. The method of
the invention comprises determining the energy of a received signal in sub-
bands narrower than the broadband communications system frequency band,
calculating an average of the energies of the sub-band signals, comparing the
energies of the desired sub-band signals with the average of the sub-band

15   signal energies and cancelling interference if any of the sub-band signal ener-
gies exceeds the average by a predetermined threshold value. .

The invention also relates to an arrangement for cancelling inter-
fering narrowband signals in a receiver of the broadband communications
system. In the arrangement according to the invention, the receiver comprises

20   means for determining the energy of a received signal in sub-bands narrower
than the frequency band of the broadband communications system, means for
calculating the average of the sub-band signal energies, means for comparing
the energies of the desired sub-band signals with the average of the sub-band
signal energies and means for cancelling interference if any of the sub-band

25   signal energies exceeds the average by a predetermined threshold value.

The preferred embodiments of the invention are disclosed in the
dependent claims.

Several advantages are achieved with the method and arrangement
according to the invention. Interference cancellation is implemented in the ra-

30   dio frequency parts, which allows to minimize the interference caused to the
baseband parts. The frequencies used by the interfering narrowband systems
need not be known in advance. Hence, the method is also applicable to can-
cellation of interference caused by a frequency-hopping or an unknown inter-
fering system. Additionally, according to the invention, it is possible to improve

35   the performance of the broadband system receiver also in a situation where
interference originates from a plurality of sources. In that case, the interfer-

ence is background noise in nature having numerous high-power peaks such that filtering of all narrowband signals is not possible without losing the desired signal information excessively. In these cases, power of the signal received from the channel is clipped to a desired, predetermined level, whereby the broadband signal itself will not be clipped at all, because its power level does not exceed the average. The method according to the invention is simple to implement, because the signal and the interference need not be regenerated using various signal transformation methods.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention will be described in connection with preferred embodiments, with reference to the attached drawings, wherein

Figure 1 illustrates the general structure of the described spread spectrum system;

Figure 2 illustrates a situation where the described narrowband and broadband systems are used simultaneously;

Figure 3 illustrates interference caused by the narrowband system to the broadband system band on the frequency level;

Figure 4 is a flow chart of one solution according to the invention;

Figure 5 shows the effect of one solution according to the invention on a band of a broadband signal on the frequency level;

Figure 6a is a block diagram of a receiver structure implementing one solution according to the invention;

Figure 6b is a block diagram of a receiver structure implementing one solution according to the invention, when the solution according to the invention is applied separately to either receiver branch;

Figure 7 is a flow chart of another solution according to the invention;

Figures 8a to 8c illustrate the effect of another solution according to the invention on the frequency level;

Figure 9a is a block diagram of a receiver structure implementing another solution according to the invention;

Figure 9b is a block diagram of a receiver structure implementing another solution according to the invention, when the solution according to the invention is applied separately to either receiver branch.

6

DETAILED DESCRIPTION OF THE INVENTION

The present invention can be applied to a plurality of different types of situations where the narrowband and the broadband communications systems use the same frequency or adjacent frequencies simultaneously. In a
5   simultaneous use situation of this kind, the narrowband signal, such as a signal in the GSM system, having a considerably higher power, can significantly degrade the performance of a receiver in the broadband system, such as the WCDMA system, or even block it.

The invention can also be applied to reduce the interference level
10   caused by background noise peaks produced by a plurality of other interference signals, typically resulting from human activity, in a receiver of the broadband system, of which one example is the WCDMA system. In the following, the invention will be described in connection with the GSM and the WCDMA systems, without restricting thereto in any way, however. The invention can be
15   applied to all receivers of the broadband communications systems: to network parts, such as base stations, and to various subscriber terminals alike.

In the following, the principle of one embodiment of the invention is described by means of the flow chart of Figure 4. In the embodiment of the invention described herein, a control signal is generated, by means of which a
20   band-stop filter is tuned to a desired frequency. In this embodiment of the method according to the invention, the frequency band of the received signal is split into sub-bands, whose bandwidth is preferably defined by the bandwidth of an interfering narrowband system. In the case of the GSM system, the width of the sub-band is 200 kHz. The energy of the received signal is deter-
25   mined, for instance by an integrator, on each sub-band 400, whereafter the average of the measured signal energies is calculated 402. The signal energy of each sub-band is compared with the calculated energies of all sub-band signals, and if any of the sub-band signal energies exceeds the average by a predetermined threshold value 404, the band-stop filter is tuned to the fre-
30   quency of said sub-band 406, whereafter the sub-band is filtered 408. If none of the sub-band signal energies exceeds the threshold value, the band-stop filter is not used.

Figure 5 illustrates the effect of the above-described embodiment of the invention on the frequency level. In this case, a 200 kHz band 400 has
35   been filtered out from the frequency band of the WCDMA signal 300. Thus, due to the filtering of the interfering signal, interference caused by the signal

coming to the baseband parts is the least possible, and the receiver will not be blocked. If the employed system comprises two receivers, and the above-described method according to the invention is applied to only one receiver branch, a band is removed from the WCDMA signal only in said branch,
5   whereby part of the signal in this 200kHz band remains.

Figure 6a shows a block diagram of the receiver structure, when one embodiment of the invention is used for interference cancellation from the signal received from the main branch receiver. An incoming signal to the receiver 600 or a diversity receiver 602 may comprise, in addition to the
10   WCDMA signal containing the desired information, other signals of the same WCDMA system and at least one interference signal, which in this description of the preferred embodiment of the invention is a GSM signal. The solution of Figure 6a utilizes the improvement in the system performance provided by diversity reception. The diversity reception is not essential in any way to the in-
15   vention, but the invention can also be applied in the case of one receiver. After the radio frequency front formed by the receivers, the signal is stored in a buffer memory 606 and the frequency band is split into frequency sub-bands of a predetermined width, in which the signal energy is determined by splitting and calculating means 608. The buffer memory and the splitting and calculat-
20   ing means can change places as indicated in Figure 9. The methods, by which the signal energy is calculated, are well known in the field and they will not be explained in greater detail herein, since the application of the invention does not restrict in any way the implementation of the above-mentioned signal energy calculation operations.

25   The average of the sub-band energies is calculated next by the calculating means 610. According to the most preferable implementation alternative, the energies of all sub-bands are used for the calculation of the average, but some other selection is also possible, for instance, for making the calculation faster. If any of the sub-band signal energies exceeds the average by a
30   predetermined threshold value, the band-stop filter is tuned to the frequency of said sub-band. Comparison of the sub-band signal energies with the average and the tuning of the band-stop filter are implemented by comparing and tuning means 612. The comparison of the sub-band signal energies with the average is typically implemented by means of a processor, software comprising
35   necessary commands, or logic circuits. The tuning methods of the filter 614 are well known in the field, and the application of the invention does not re-

8

strict the selection thereof. The band-stop filter 614 tuned to the selected fre-
quency filters the selected sub-band out from the received signal 620. The
diversity receiver signal is applied as such onto a baseband combiner 618
without applying an interference cancellation algorithm according to the inven-
5   tion. Thus, inconveniently powerful interference signals have been removed
from the signal to be conveyed to the baseband parts 616. If the interfering
system concerned comprises baseband hopping and its hopping pattern is
known, the embodiment of the invention can be made faster such that the en-
ergy of the received signal is calculated sub-band-wise according to the inven-
10   tion only on the current sub-band used by the interfering system and a previ-
ously calculated average or a typical average calculated by statistical methods
is used as the reference average.

        Figure 6b describes how the interference cancellation algorithm ac-
cording to the invention can also be applied to either receiver branch sepa-
15   rately. In that case, both the main branch receiver 600 and the diversirty
branch receiver 602 each have specific buffer memories 606a-b, splitting and
calculating means 608a-b, average calculating means 610a-b, comparing and
tuning means 612a-b and filters 614a-b. Thus it is possible to select whether
the method of the invention is applied to either branch or to one branch only.
20   By means of the separate filters, it is possible to filter interference signals of
different frequencies out from either branch. It is advantageous that the re-
ceived signal 620 or 622 is filtered only in one receiver branch if the interfer-
ence signal is received in one receiver branch only, because this is how the
information signal is lost as little as possible.

25   If there are a plurality of interfering signals having a narrow band in
comparison with the system employed, for instance several GSM interference
sources or other typically man-made signal peaks, it is advantageous to apply
the embodiment of the invention that will be described next by means of the
flow chart of Figure 7. In this embodiment of the method according to the in-
30   vention the frequency band of the received signal is split into sub-bands
whose bandwidth is typically determined to be the bandwidth of an interfering
system if known. If the interfering system is unknown, it is possible to attempt
to determine the necessary sub-band width, for instance, by advance meas-
urements or by utilizing the knowledge of systems potentially used in the area.
35   After determining the sub-band width to be used, the energy of the received
signal is measured, for instance by an integrator, on each sub-band 700,

9

whereafter the average of the measured signal energies is calculated 702. The signal energy of each sub-band is compared with all measured sub-band signal energies and if the signal energy in any sub-band exceeds the average by a predetermined threshold value 704, the power of said sub-band signal is

5   clipped to the level of the average power, or to the level which is the average power added with a predetermined threshold value 706. If none of the sub-band signal energies exceeds the threshold value, the power of none of the sub-band signals is clipped.

Figures 8a to 8c illustrate the effect of the above-described em-

10   bodiment of the invention on the frequency level. Figure 8a illustrates a broadband signal 800 on a channel, to which various interference signals 500 are summed. As appears from the figure, the power of the interference signals can be considerably higher than the power of the desired transmission signal. Figure 8b illustrates how a level 802 is set according to the invention, typically the

15   average added with a predetermined threshold value, so as to clip the interfering power peaks. Figure 8c shows the power of the signal 800 on the frequency level after the power peak clipping.

Figure 9a shows a block diagram of the structure of a receiver implementing one embodiment of the invention. The signal coming to the re-

20   ceiver 900 or the diversity receiver 902 may comprise, in addition to the WCDMA signal containing the desired information, other WCDMA signals and background noise which contains narrowband-type interference signals, such as GSM transmissions. The solution of the figure utilizes improved system performance provided by the diversity reception. Use of diversity in signal re-

25   ception is in no way essential to the application of the invention, but the preferred embodiment of the invention described herein can also be applied without a diversity receiver. In the solution of the figure, interference cancellation to be described next is not performed on the diversity branch signal 904, but the signal is directly applied to a baseband combiner 916. The reason for this

30   is that in certain circumstances it may be possible that a narrowband interference signal is not summed to all multipath-propagated signal components, for instance. Instead, the frequency band of the signal received by the main branch is split into frequency sub-bands of a predetermined width, in which sub-bands the signal energy is measured by splitting and calculating means

35   906, whereafter the values are stored in a memory 908. The buffer memory and the splitting and calculating means can change places, as appears from

10

Figure 6. The manner described herein has an advantage that the require-
ments for the component(s) used as buffer memory are not as strict as those
in the solution of Figure 6. The methods, by which the signal energy is calcu-
lated, are well known in the field and they will not be explained in greater detail

5   herein, since the application of the invention does not restrict in any way the
implementation of the above-mentioned signal energy calculation operations.

The average of the sub-band signal energies is calculated next by
calculating means 910. According to the most preferable implementation alter-
native, the energies of all sub-bands are used for the calculation of the aver-

10   age, but some other selection is also possible, for instance, for making the
calculation faster. Next, the energy of each sub-band signal is compared with
the calculated energy average by comparing means 912. The comparison of
the sub-band signal energies with the average is typically implemented with a
processor, by means of software or logic circuits. If any of the sub-band signal

15   energies exceeds the average by a predetermined threshold value, the power
of said sub-band signal is clipped by clipping means 914 to a predetermined
level which typically is the average or the average added with the desired
threshold value. Finally, the separate sub-band signals and the diversity
branch signal are combined with a baseband combiner 916 into one signal to

20   be forwarded to base band parts 918. In this manner, the preferred embodi-
ment of the invention equalizes the background noise coming to the receiver
by deleting the sudden power peaks caused by the interference signals
summed thereto. A previously calculated average or a typical average calcu-
lated by statistical methods can be used as reference average, so as to make

25   the method faster, if necessary.

Figure 9b describes how the interference algorithm according to the
invention can be applied to either receiver branch separately. In that case,
both the main branch receiver 900 and the diversity branch receiver 902 each
have specific frequency sub-band splitting means and signal energy calculat-

30   ing means 906a-b, buffer memories 908a-b, means for calculating the average
of the sub-band signal energies 910a-b, means for comparing the sub-band
signal energies with the average 912a-b and the signal level clipping means
914a-b. Also in this embodiment the buffer memory and the splitting and cal-
culating means can change places, as shown in Figure 6. In this solution it is

35   possible to select whether the method of the invention is applied to either
branch or to one branch only. When the method of the invention is applied to

either receiver branch, the frequency bands to be clipped can be selected for different branches independently.

Even though Figures 6a-b and 9a-b only show a receiver structure comprising the main branch and one diversity branch, it is obvious to a person skilled in the art that the receiver structure can also be of some other kind, for instance, comprising three diversity branches and one main branch, to all of which or some of which the solution of the invention can be applied. In addition, it is also obvious that the interference cancellation algorithm according to the invention can also be applied antenna-beam-specifically, not only receiver-specifically, typically in systems employing directional antennae.

Even though the invention is described above with reference to the example of the drawings, it is clear that the invention is not restricted thereto but it can be modified in a variety of ways within the scope of the inventive idea disclosed in the attached claims.

CLAIMS

1. A method for cancelling interfering narrowband signals in a receiver of a broadband communications system, c h a r a c t e r i z e d by determining the energy of a received signal in sub-bands narrower
5   than the broadband communications system frequency band, calculating an average of the energies of the sub-band signals, comparing the energies of the desired sub-band signals with the average of the sub-band signal energies and cancelling interference if any of the sub-band signal energies exceeds the average by a predetermined threshold value.

10   2. A method as claimed in claim 1, c h a r a c t e r i z e d by measuring the energies of the sub-band signals in the entire receiving frequency band by splitting the frequency band into sub-bands of a predetermined width.

3. A method as claimed in claim 1, c h a r a c t e r i z e d in that the sub-band width is defined by the interfering narrowband system and that the
15   sub-band signal energies are only measured according to the frequency hopping pattern of the interfering frequency-hopping narrowband system on the frequency bands in use at a particular time.

4. A method as claimed in claim 1, c h a r a c t e r i z e d in that the sub-band width equals the bandwidth of the interfering narrowband system
20   and that the sub-band signal energies are only measured according to the frequency hopping pattern of the interfering frequency-hopping narrowband system on the frequency bands in use at a particular time.

5. A method as claimed in claims 2 to 4, c h a r a c t e r i z e d in that interference is cancelled by clipping the sub-band signal power to a pre-
25   determined level.

6. A method as claimed in claims 2 to 4, c h a r a c t e r i z e d in that interference is cancelled by clipping the sub-band signal power to the average power level.

7. A method as claimed in claims 2 to 4, c h a r a c t e r i z e d in
30   that interference is cancelled by clipping the sub-band signal power to the level which is the average power added with a predetermined threshold value.

8. A method as claimed in claims 2 to 4, c h a r a c t e r i z e d in that interference is cancelled by filtering one or more sub-bands selected on the basis of the sub-band signal energy measurement from the received
35   broadband signal by at least one filter.

13

9. A method as claimed in claims 5 to 8, **c h a r a c t e r i z e d** in that interference is cancelled from the composite signal of the signals received from the main branch receiver and at least one diversity receiver.

10. A method as claimed in claims 5 to 8, **c h a r a c t e r i z e d** in
5   that interference is cancelled from the signal received by the main branch receiver and from the signal received by at least one diversity receiver separately.

11. A method as claimed in claims 5 to 8, **c h a r a c t e r i z e d** in that interference is cancelled from the signal received in the main branch of
10   the receiver.

12. A method as claimed in claims 5 to 8, **c h a r a c t e r i z e d** in that interference is cancelled from the signal received in at least one diversity receiver.

13. A method as claimed in claims 5 to 8, **c h a r a c t e r i z e d** in
15   that interference is cancelled antenna-beam-specifically.

14. An arrangement for cancelling interfering narrowband signals in a receiver of a broadband communications system, **c h a r a c t e r i z e d** in that the receiver comprises means (606 to 608, 906 to 908) for determining the energy of a received signal in sub-bands narrower than the frequency
20   band of the broadband communications system, means (610, 910) for calculating the average of the sub-band signal energies, means (612, 912) for comparing the energies of the desired sub-band signals with the average of the sub-band signal energies and means (614, 914) for cancelling interference if any of the sub-band signal energies exceeds the average by a predetermined
25   threshold value.

15. An arrangement as claimed in claim 14, **c h a r a c t e r i z e d** in that the receiver comprises means (606 to 608, 906 to 908) for measuring the sub-band signal energies on the entire frequency band to be received by splitting the frequency band into sub-bands of a predetermined width.
30   16. An arrangement as claimed in claim 14, **c h a r a c t e r i z e d** in that the sub-band width is defined by the interfering narrowband system and that the receiver comprises means (606 to 608, 906 to 908) for measuring the sub-band signal energies only according to the frequency hopping pattern of the interfering frequency-hopping narrowband system on the frequency bands
35   in use at a particular time.

17. An arrangement as claimed in claim 14, **c h a r a c t e r i z e d** in that the sub-band width equals the bandwidth of the interfering narrowband system and that the receiver comprises means (606 to 608, 906 to 908) for measuring the sub-band signal energies only according to the frequency hop-
5 ping pattern of the interfering frequency-hopping narrowband system on the frequency bands in use at a particular time.

18. An arrangement as claimed in claims 15 to 17, **c h a r a c - t e r i z e d** in that the receiver device comprises means (914) for cancelling interference by clipping the power of the sub-band signal to a predetermined
10 level.

19. An arrangement as claimed in claims 15 to 17, **c h a r a c - t e r i z e d** in that the receiver device comprises means (914) for cancelling interference by clipping the power of the sub-band signal to the level of the average power.

15 20. An arrangement as claimed in claims 15 to 17, **c h a r a c - t e r i z e d** in that the receiver device comprises means (914) for cancelling interference by clipping the power of the sub-band signal to the level which is the average power added with the predetermined threshold value.

21. An arrangement as claimed in claims 15 to 17, **c h a r a c -**
20 **t e r i z e d** in that the receiver device comprises means (612 to 614) for can-celling interference by filtering one or more sub-bands selected on the basis of the sub-band signal energy measurements from the received broadband sig-nal by at least one filter.

22. An arrangement as claimed in claims 18 to 21, **c h a r a c -**
25 **t e r i z e d** in that the receiver device comprises a main branch and at least one diversity branch and is arranged to cancel interference from the composite signal of the signals received from the main branch receiver and at least one diversity receiver.

23. An arrangement as claimed in claims 18 to 21, **c h a r a c -**
30 **t e r i z e d** in that the receiver device comprises the main branch and at least on diversity branch and is arranged to cancel interference from the incoming signal of the main branch receiver and from the incoming signal of at least one diversity receiver separately.

24. An arrangement as claimed in claims 18 to 21, **c h a r a c -**
35 **t e r i z e d** in that the receiver device is arranged to cancel interference from the main branch of the receiver.

25. An arrangement as claimed in claims 18 to 21, **charac-terized** in that the receiver device is arranged to cancel interference from at least one diversity receiver.

26. An arrangement as claimed in claims 18 to 21, **charac-**
5 **terized** in that the receiver device is arranged to cancel interference antenna-beam-specifically.
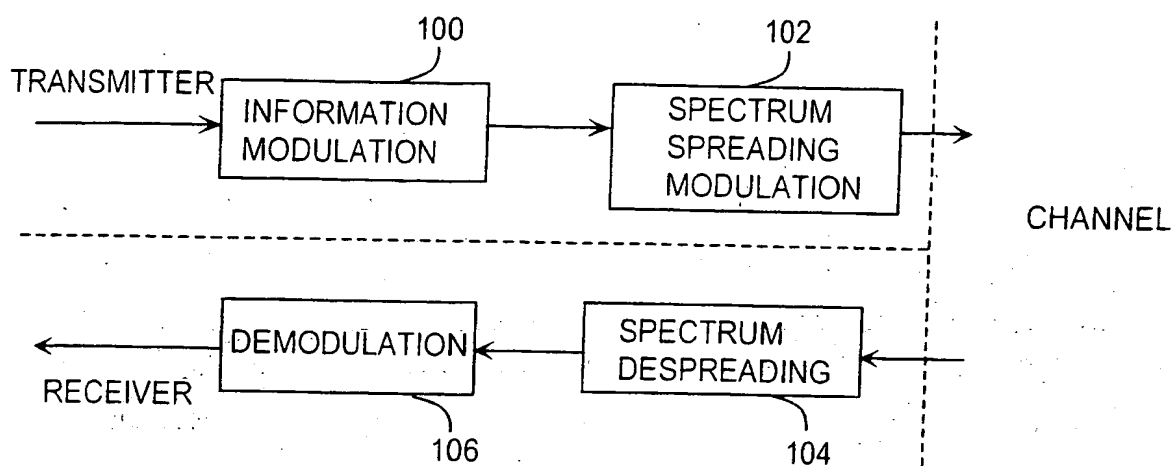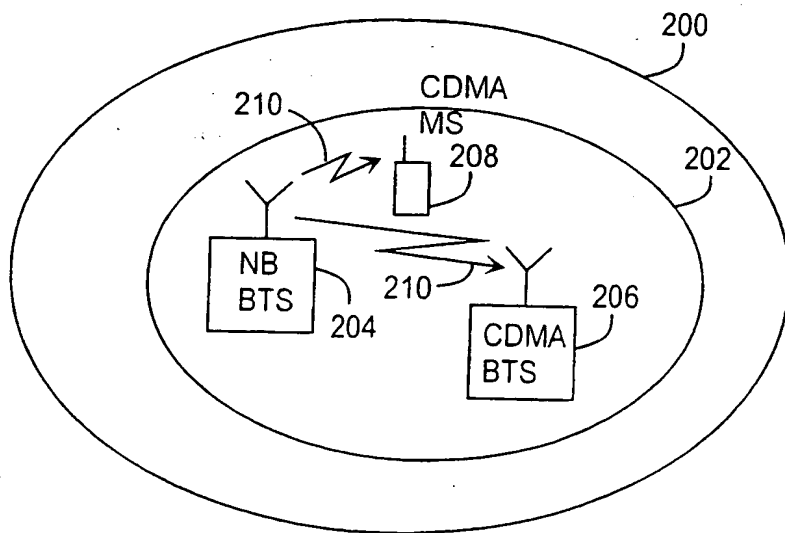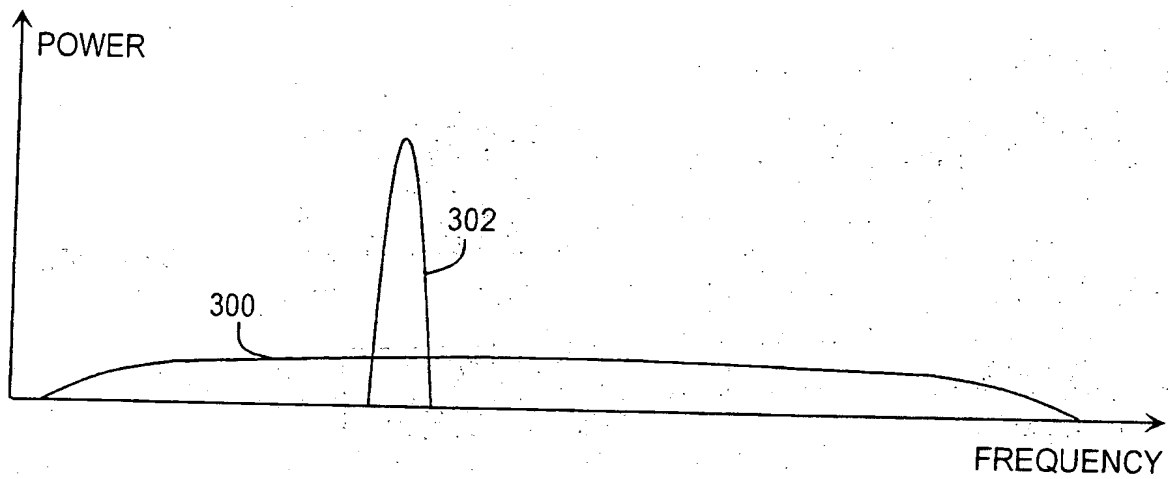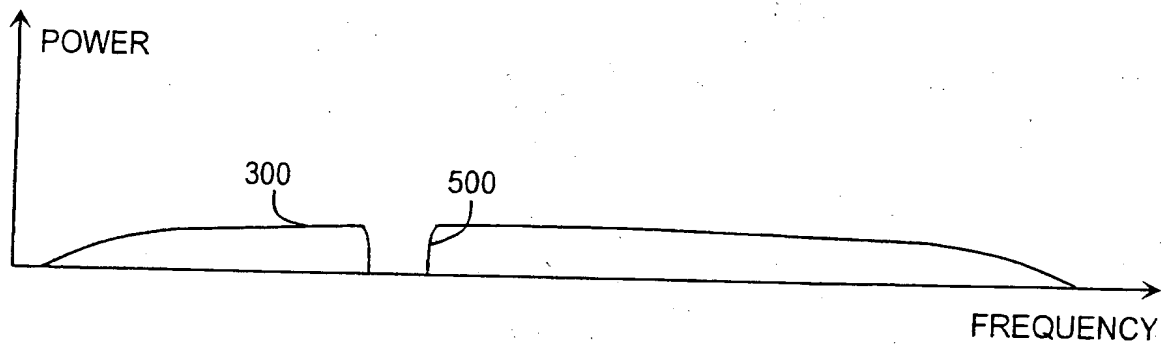
Fig. 1

Fig. 2

POWER

302

300

FREQUENCY

Fig. 3

POWER

300

500

FREQUENCY

Fig. 5

POWER

800

FREQUENCY

Fig. 8A

```
                    ( START )
                         │
                         ▼
        ┌────────────────────────────────┐
        │ DETERMINE SIGNAL ENERGY IN     │
        │ EACH SUB-BAND                  │
        │                          400   │
        └────────────────────────────────┘
                         │
                         ▼
        ┌────────────────────────────────┐
        │ CALCULATE AVERAGE OF ENERGIES  │
        │                          402   │
        └────────────────────────────────┘
                         │
                         ▼
                 ◇─────────────◇
               /                 \         NO
              <  SUB-BAND ENERGY   >─────────────┐
               \ EXCEEDS AVERAGE? 404            │
                 ◇─────────────◇                 │
                         │  YES                   │
                         ▼                        │
        ┌────────────────────────────────┐        │
        │         TUNE FILTER            │        │
        │                          406   │        │
        └────────────────────────────────┘        │
                         │                        │
                         ▼                        │
        ┌────────────────────────────────┐        │
        │       FILTER SUB-BAND          │        │
        │                          408   │        │
        └────────────────────────────────┘        │
                         │                        │
                         ◄────────────────────────┘
                         ▼
                    ( END )
```

Fig. 4

4 / 9

Fig. 6A

5 / 9

Fig. 6B

START

DETERMINE SIGNAL ENERGY IN
EACH SUB-BAND   700

CALCULATE AVERAGE OF ENERGIES
                                   702

SUB-BAND ENERGY
EXCEEDS AVERAGE?   704   NO

YES

CLIP SUB-BAND SIGNAL POWER
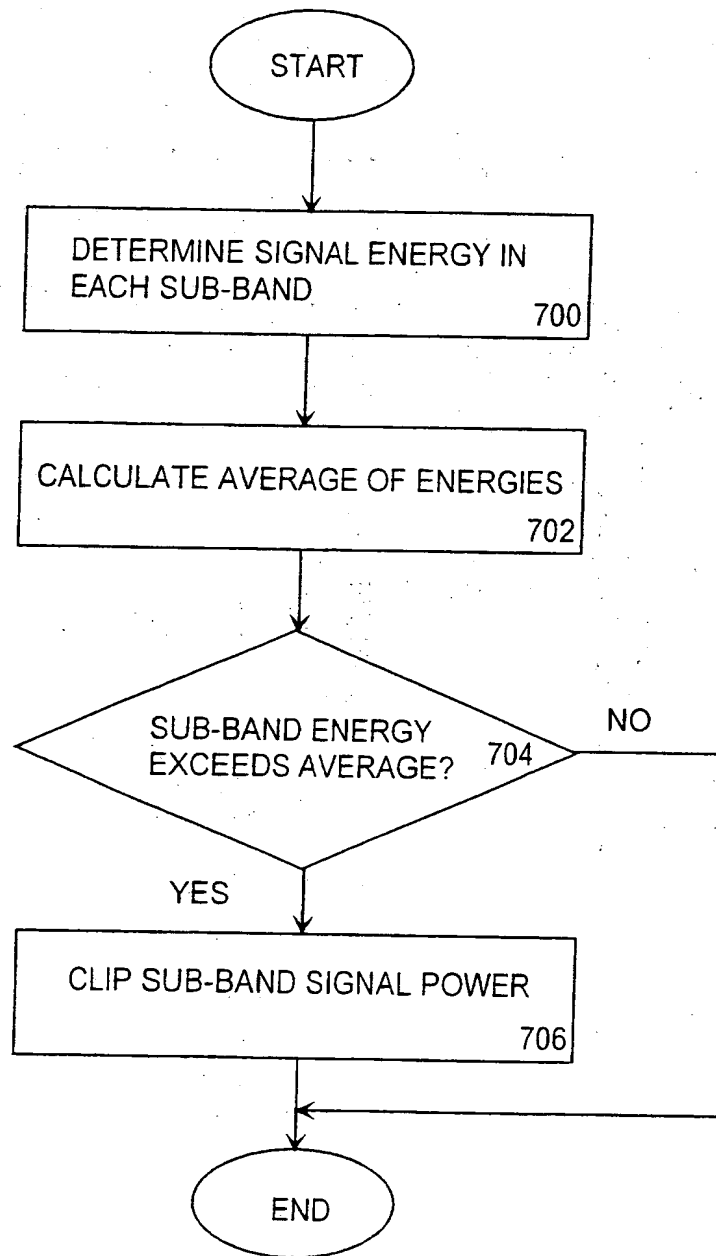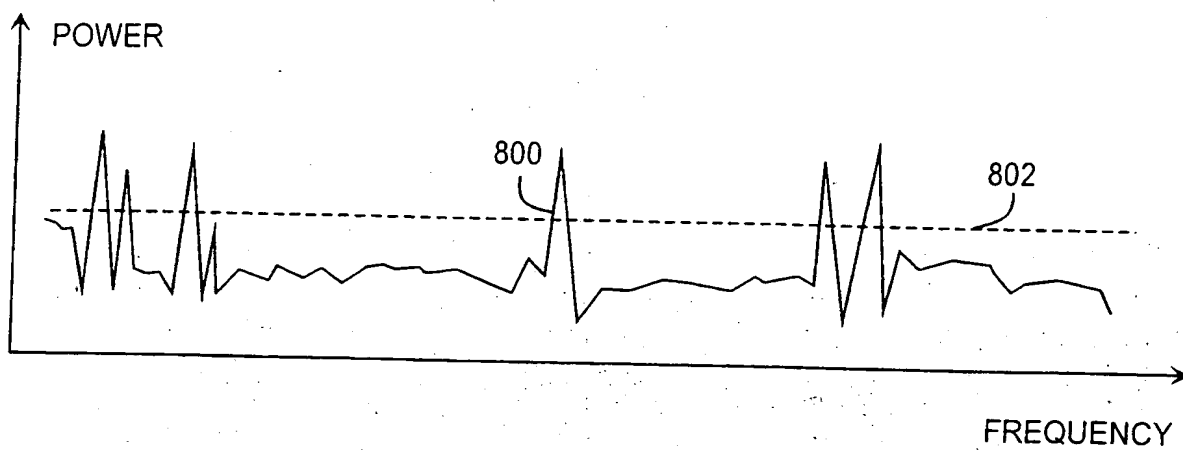   706

END
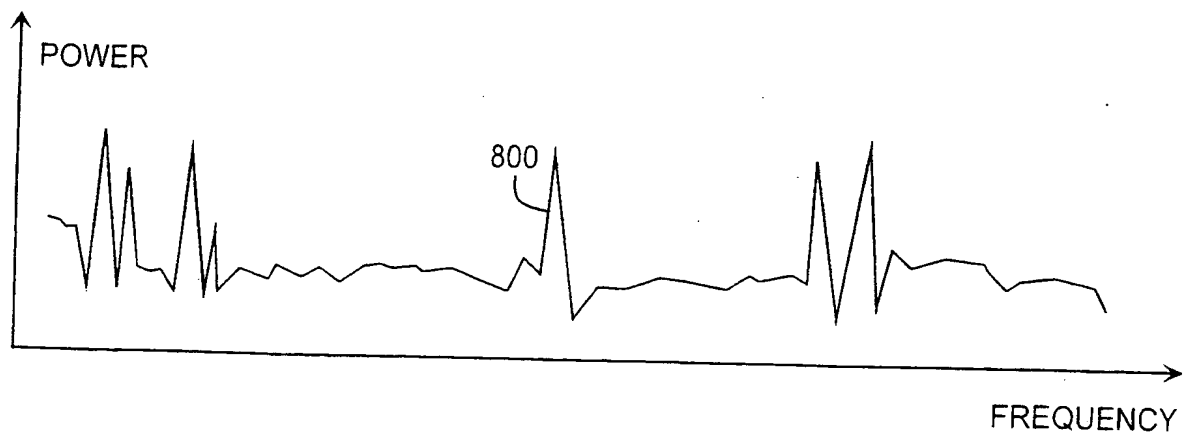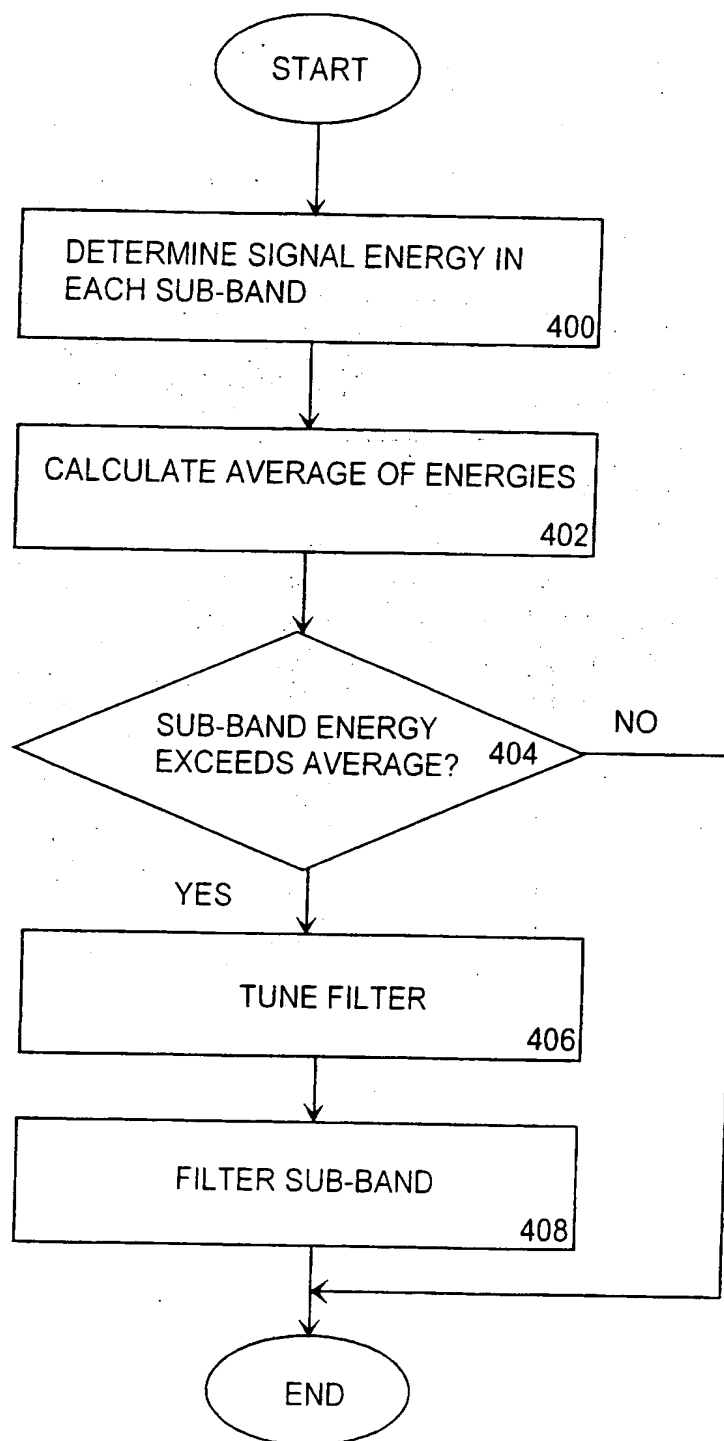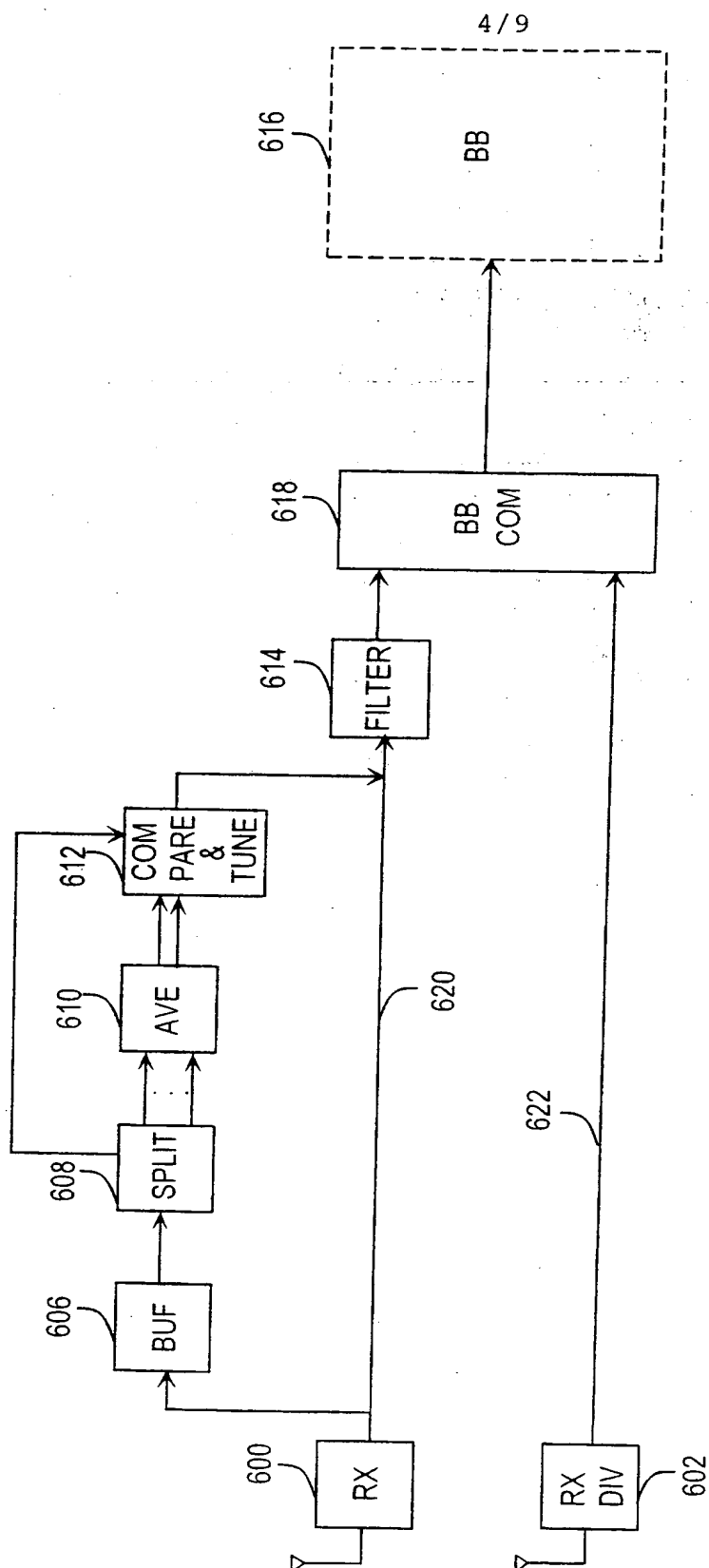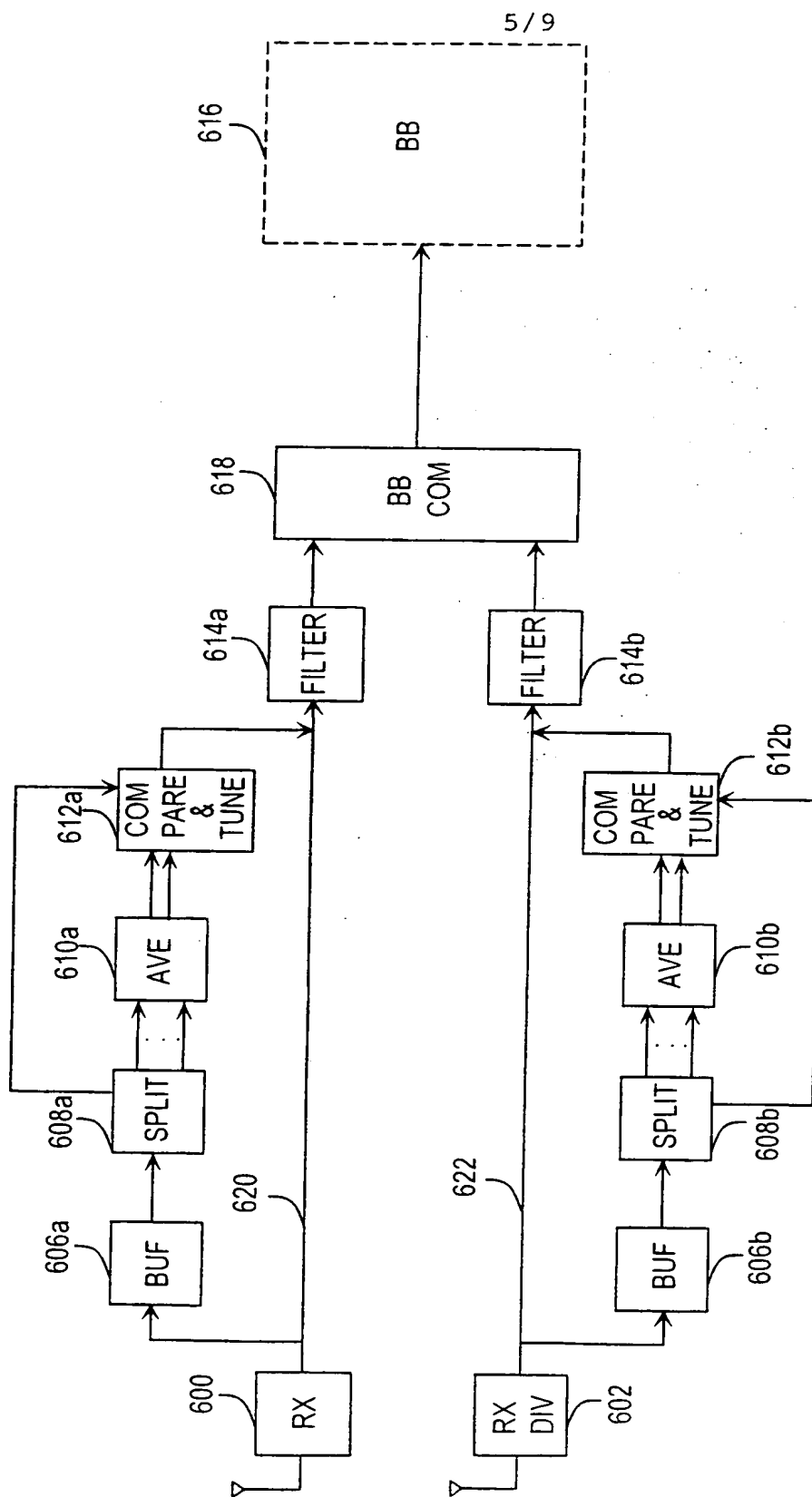
Fig. 7

Fig. 8B
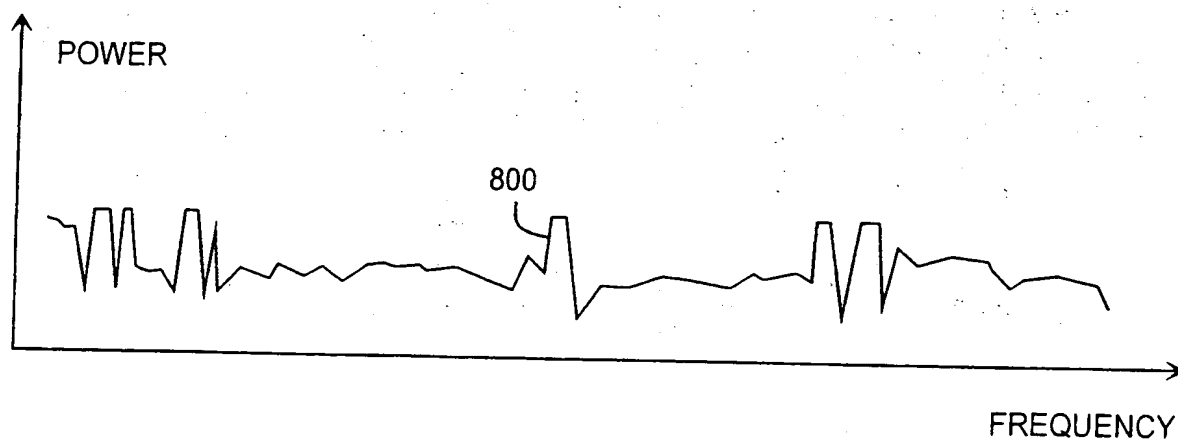
Fig. 8C
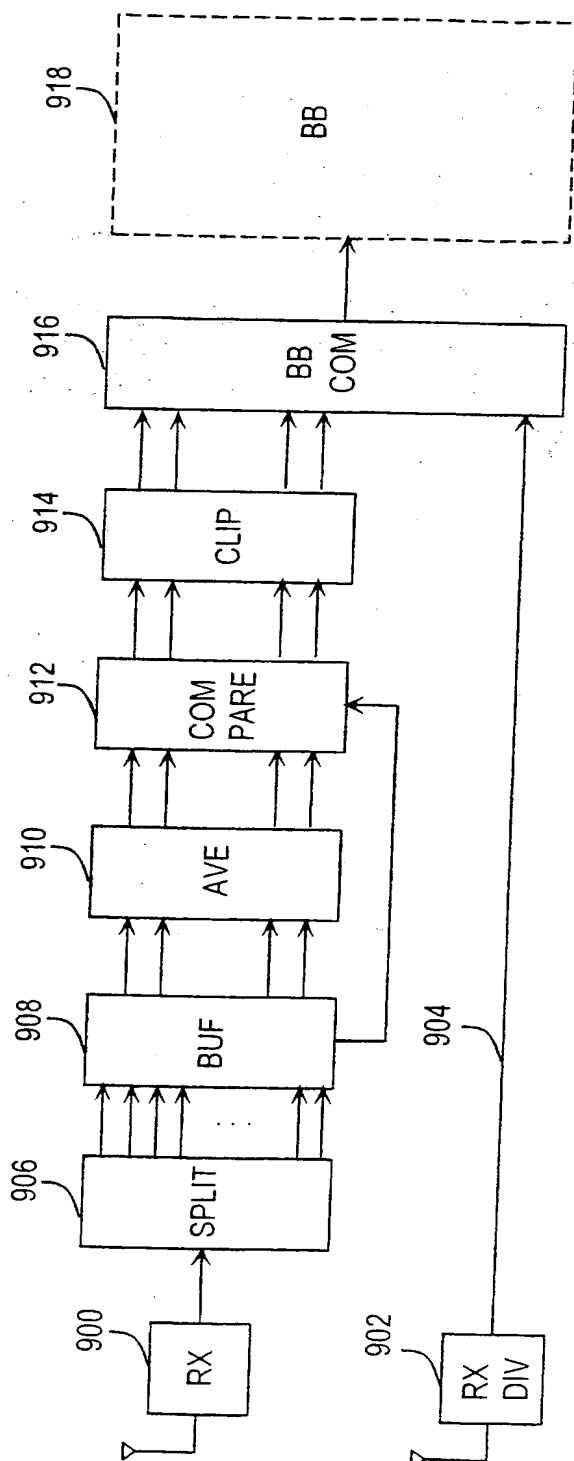
Fig. 9A
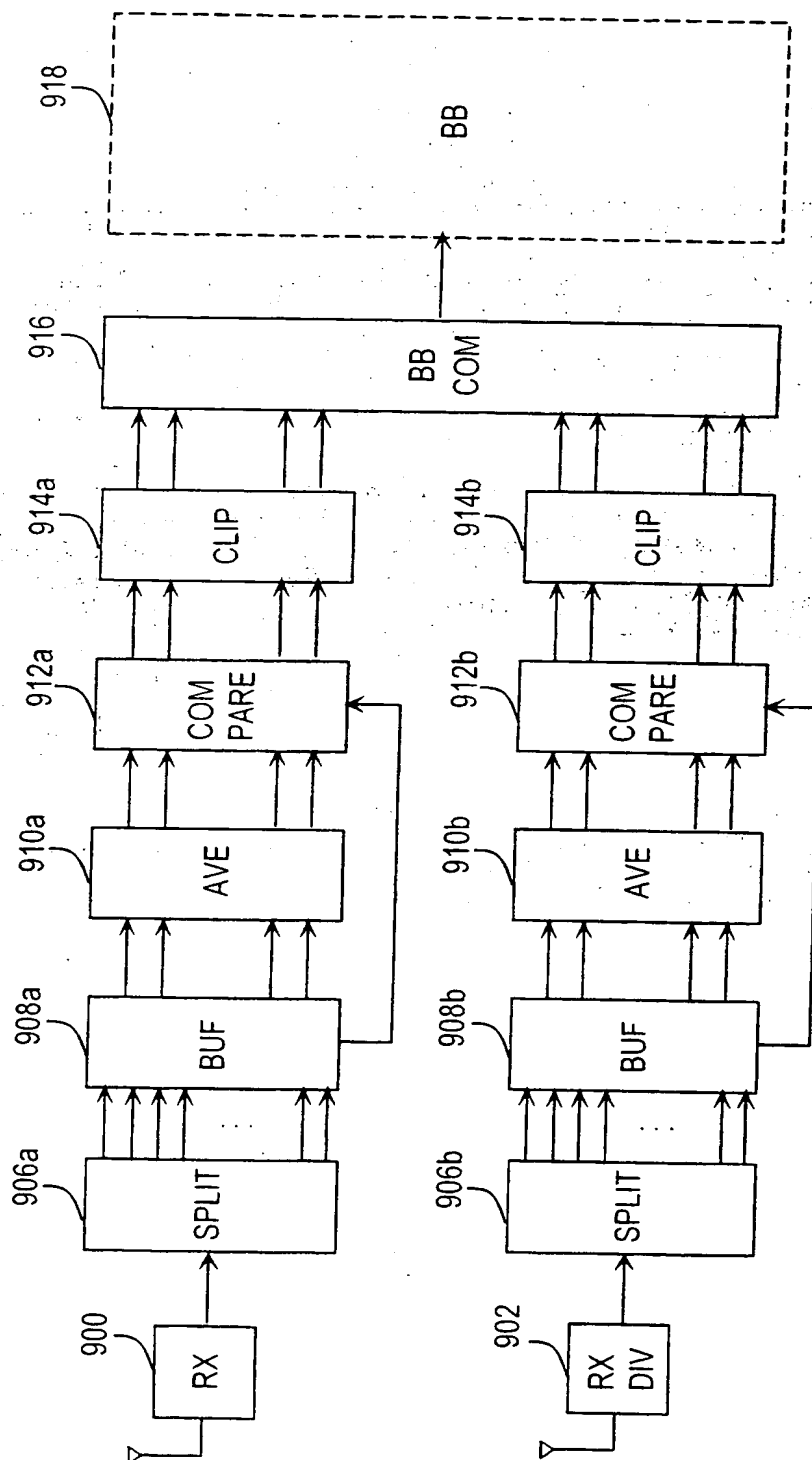
Fig. 9B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/01158

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04B 1/707, H04B 1/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5974101 A (HIDETADA NAGO), 26 October 1999 (26.10.99), column 8, line 43 - line 61; column 13, line 33 - column 14, line 14; column 35, line 36 - column 36, line 56	1,2,5-8,11, 14,15,18-21, 24
A		3,4,9,10,16, 17,22,23
	--	
X	US 5168508 A (KENJU IWASAKI ET AL), 1 December 1992 (01.12.92), column 3, line 28 - column 4, line 55	1,2,5-7,11, 14,15,18-20, 24
A		3,4,8-10,16, 17,21-23
	--	

X	Further documents are listed in the continuation of Box C.	X	See patent family annex.

Date of the actual completion of the international search	Date of mailing of the international search report
4 April 2001	0 6 -04- 2001

Name and mailing address of the ISA:	Authorized officer
Swedish Patent Office	
Box 5055, S-102 42 STOCKHOLM	Bo Gustavsson/mj
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Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 00/01158

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4613978 A (RICHARD R. KURTH ET AL), 23 Sept 1986 (23.09.86), claims 1,2 --	1,5-8,11,14, 18-21,24

A	US 5612978 A (SCOTT D. BLANCHARD ET AL),
	    18 March 1997 (18.03.97), column 2,
	    line 17 - column 3, line 25; column 4,
	    line 16 - column 5, line 4
	
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		1,3-8,11,14,
		16-21,24

International application No.
PCT/FI 00/01158

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
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				JP 2083053 C		23/08/96
				JP 4091528 A		25/03/92
				JP 7105746 B		13/11/95
				JP 2056452 C		23/05/96
				JP 4150331 A		22/05/92
				JP 7079282 B		23/08/95
US	4613978	A	23/09/86	NONE		
US	5612978	A	18/03/97	NONE		